Helicopter Strakes

A NASA AERODYNAMIC INNOVATION SOLVES A PROBLEM OF HELICOPTER FLIGHT

In hovering or low speed flight, a single rotor helicopter experiences significant aerodynamic loads, or downward pressuring forces, on the fuselage and tail assembly. This is due to combinations of wind, maneuvers and downwash from the main rotor. The download is offset by increasing the thrust of the main rotor and the tail rotor, but that costs a penalty in payload or performance.

In the late 1980s and early 1990s, Langley Research Center sought a way to correct this problem and focused on the concept of using strakes on a helicopter's tail boom. A strake is a "spoiler" whose purpose is to alter the airflow around an aerodynamic body to get some kind of benefit. In this case, the intent was to change beneficially the loading on the tail boom of a single rotor helicopter, which can experience limitation of tail rotor power and directional control when it is flying sideward to the right or hovering in wind coming from the right (main rotor torque accentuates the drag force effect in right sideward flight).

Langley conducted wind tunnel experiments with strakes of different sizes mounted at various locations on representative tail boom models of several helicopter types, measuring the forces on the boom under a variety of wind speed and flight conditions. These tests were followed up by flight testing of a strake-equipped helicopter at NASA's Wallops (Virginia) Flight Facility.

Langley's research demonstrated that properly placed strakes mounted on a tail boom change the air loading, reduce the thrust and power requirements of a tail rotor, and provide an economical way to improve helicopter low speed flight handling qualities, particularly in right sideward flight. The center's work led to incorporation of tail boom strakes on three production-type commercial helicopters.

One of the three is the MD520N, introduced to service in 1992, which was developed by McDonnell Douglas Helicopter Company, Mesa, Arizona. The MD520N is an innovative helicopter that has no tail rotor. A tail rotor is normally employed to offset the twisting moment—known as torque—created by a helicopter's main rotor. Torque tends to make the aircraft turn in a direction opposite to the main rotor's rotation. The tail-rotor is an anti-torque device; it prevents the tendency to turn and thus provides directional control.

In place of the tail rotor, the MD520N has a NOTAR™ (No Tail Rotor) anti-torque system in which "sheets" of air are ejected through slots on the right side of the tail boom; this air deflects the wake of the main rotor around the tail boom and produces an aerodynamic side force. In hover and low speed flight, this side force provides 60 percent of the required anti-torque moment needed to balance the torque generated by the main rotor. The slotted, air ejecting

tail boom is known as a "circulation control" boom.

In developing the MD520N, McDonnell Douglas Helicopter Company conducted an extensive research effort aimed at enhancing the performance of the circulation control type of tail boom. The company made use of much of the conceptual and testing information provided by Langley Research Center's investigation into the effectiveness of tail boom strakes on conventional tail rotor helicopters. McDonnell Douglas' work focused on determining the strake location at which tail boom anti-torque force is greatest and tail boom download is least for the circulation control NOTAR helicopter.

The research started with wind tunnel tests of model tail booms and proceeded to full scale wind tunnel testing of the NOTAR tail boom. ***At left***, a strake-equipped tail boom is mounted vertically in the company's open jet wind tunnel; wind blows from a jet nozzle at right over the tail boom, then exits through a collector at left. ***Above***, the experimental MD520N is undergoing sideward flight test with an instrumented tail boom and strake at the company's Mesa facility. ***At right*** is a closeup of the tail boom with a strake (white area) optimized for height, length and location on the basis of flight test data; what seem like blemishes on the shiny surface are pressure instrumentation ports for measurement of aerodynamic forces. The research led to the incorporation of strakes on MD520N production models; the strake is very light (less than two pounds), simple in design and easily integrated in the helicopters. •

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